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TECHNICAL REPORT
NATICK/TR-86/003

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SEALING MUSTARD JARS WITH PLASTIC LINERLESS CLOSURES

BY
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OCTOBER 1985

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SEALING	MUSTARD
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CONDIMENTS	PLASTIC LIDS
SHELF LIFE	MOISTURE/VAPOR TRANSFER

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

The purpose of this study was to test the effect of a proposed new state-of-the-art plastic linerless closure to be used on one-quart (2-pound) and one-gallon glass jars to package mustard for the military. Product was received, packaged according to military requirements except for lids, and vibrated to simulate shipping conditions and to determine whether the caps performed as intended. Also, accelerated storage studies were conducted on mustard product evaluating its sensory and chemical parameters. Results indicated that the Suncoast plastic

liner tested would be suitable for at least minimum protection known in the military as level C. These lids should be included in EE-M-821 for the next procurement in order for the Government to realize savings by allowing contractors a choice of either plastic or metal. Specification requirements should be written so that they protect the Government against inferior plastic closures - those that loosen, leak, or do not adequately protect the product. Mustard was found to be very stable on accelerated storage, with little loss in acceptance.

Preface

This project was initiated as a result of a value engineering change proposal from Robbins Sales Co., Inc., New York, N.Y. (during execution of Contract DLA13H-83-C-0895) to allow plastic in lieu of metal closures on prepared mustard in glass jars.

Armed Forces' experience with plastic lids was limited, and Natick R&D Center had encountered problems with caps loosening due to vibration during handling. In addition, military products move worldwide under all environmental extremes. To avoid product failure, Natick R&D Center recommended a pilot test of the use of Sun Coast plastic closures on one-quart (two-pound) and one-gallon mustard jars. This project was assigned Value Engineering Change Proposal number DPSC-S-VECP-49-83.

The authors wish to express their sincere gratitude to two special people: Mrs. Edna Albert, who aided in making our communication more meaningful and effective by setting up the format and illustrative material in a more readable manner; and Mrs. Nancy Ring, for her patience and skillful use of the word processor.

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INTRODUCTION

To seal glass jars containing food, metal screw caps with liners have been in common commercial and military use for decades. As a cost-cutting measure, many commercial manufacturers have replaced metal lids on glass jars with plastic closures. As a rule of thumb, if the number of caps purchased are in quantities of 100,000 or fewer, plastic is more economical. If a large volume of one product is sold, for example, 10 million units, metal caps could be cheaper than plastic. Most military procurements for condiments are in the former category.

Current DLA contract is 75,000 jars of mustard. The use of plastic closures could save the government over $1500 on this item alone. Multiply this savings times many other items and contracts, and the savings to the government could be sizeable.

In addition, there are technical factors to consider: the product itself - does it react with the closures? Consider the shelf life - how long is the usable life of the product? There are also ecological considerations: does the trash created, or do the jars themselves, pose a threat to the environment? The latter question, although important, is not addressed in this report. The main consideration addressed here is the product and its shelf life. According to the report by Rutgers University Packaging Science & Engineering, authored by Mary Amini and Darrell Morrow, titled "Performance Evaluation of High Density Polyethylene Linerless

closures for Sun Coast Plastic Closures, Inc.", 1980, the most important factors in determining the shelf life of many products are the rates at which gases and vapors enter or leave the package.[1] The rate of moisture vapor transfer to and from the product and the barrier properties of the package are the main determinants of the shelf life of the product in question, assuming no other factors are taken into account. Fig.1 illustrates the product manufactured by Sun Coast that was used in the study.

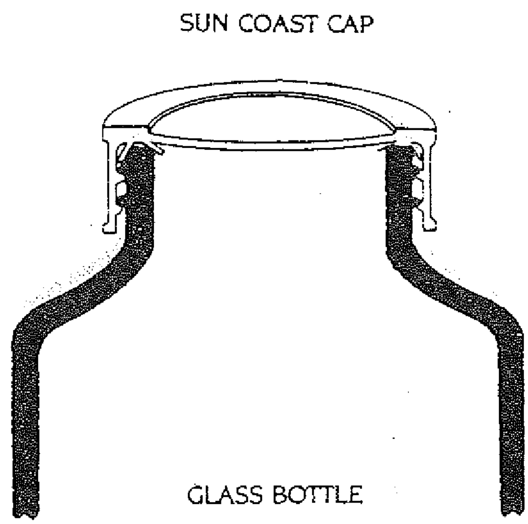

Figure 1. Unlined plastic lid used on test.

Gas or vapor transport can occur by two mechanisms: leakage and permeation. In both cases, the components inside and outside the package are trying to equalize their concentration.

The Rutgers University report provided much useful theoretical data on predicting leakage and permeation using this closure in general, but left the void of not studying mustard specifically. Our aim was to focus on the use of plastic lids on glass jars containing mustard and determine their effect on the quality of the product in a simulated life cycle use.

Cased product was abused in a handling test to determine if the caps would come loose, leak, or crack. If the lids performed satisfactorily, the product was stored and evaluated at designated intervals by sensory and chemical assays.

METHOD OF PREPARATION

Handling tests were conducted on mustard in jars (Federal Specification EE-M-821, Type I, 2-pound glass, National Stock No. 8950-01-074-3920)[2] with the jars packed in accordance with Federal Specification PPP-G-460.[3]

Each of the one-gallon and one-quart jars were repacked into new V3c RSC case containers with 275-pound test DW liners, partitions, and top and bottom pads, in accordance with Federal Specification PPP-G-460. The new case containers were fastened on top with tape and on the bottom with fiberboard adhesive.

PROCEDURES

After preparation of case containers, they were placed on the table of the laboratory vibrator at 268 rpm (equivalent to one gravity) for 60 minutes following ASTM Standard D999.[4] The test was conducted with six cases of quart jars, and five cases of one-gallon jars. After completion of the test, each of the packs was opened and the jars were examined for damage and loosening of the lids.

<u>Storage</u>. Of a total of 30 one-quart size jars with plastic lids, 10 each were stored at 40°F (control), 70°F, and 100°F. At three-month intervals, two jars from each temperature controlled room were opened and evaluated - at 0, 3, 6, 9, and 12 months. One jar was used for sensory analysis, while the other was used for chemical analysis.

<u>Sensory Evaluation</u>. Periodically, samples of mustard were withdrawn and evaluated from each of the three designated temperature controlled rooms.

<u>Consumer Acceptance Panel</u>. Bread rolls cut into four pieces were spread with mustard (one teaspoon to each roll) and evaluated by 30 panelists. Statistical analysis of the data was a randomized block ANOVA 3 of 3. Hedonic rating was the 9-point scale from "(1) dislike extremely" to "(9) like extremely". (Peryam and Pilgrim, 1957).[5]

<u>Chemical Assay</u>. Samples at each withdrawal were opened and analyzed for pH, percent acetic acid (titratable acidity), apparent viscosity, percent solids, percent crude fiber, percent nitrogen, and volatile acetic acid, using AOAC[6] methods referenced in Federal Specification EE-M-821 for Type I product.[2]

RESULTS

<u>Rough Handling</u>. The results of rough handling of both the two-pound and one-gallon jars containing mustard showed that when the jars were packed in new corrugated V3c RSC containers in accordance with Federal Specification PPP-G-460, no leakage of product or lid damage was visible.

<u>Consumer Acceptance</u>.

TABLE 1. Hedonic Ratings[a] of Mustard Jars with High-Density Polyethylene Liner Closures

Storage time (months)	Storage Temperatures 40°F	70°F	100°F	sig.	Main withdrawal effect (grand mean and mean standard deviation)
Initial 0	6.60±1.67[b]	6.73±1.41	6.47±1.57	NS[c]	6.60±1.55
3	7.11±1.28	6.97±1.13	6.72±1.28	NS	6.93±1.23
6	6.52±1.22	6.35±1.10	5.97±1.62*		6.28±1.31
9	6.89±1.21	6.47±1.56	6.44±1.48	NS	6.60±1.41
12	6.50±1.32	6.39±1.44	6.64±1.36	NS	6.51±1.37
Main treatment effect (grand mean and mean standard deviation)	6.72±1.34	6.58±1.33	6.49±1.46		

a Mean rating ranges from "(1) dislike extremely" to (9) like extremely." Source Peryam and Pilgrim (1957)
b Standard deviation
c Not significant at 0.05 level
* Significantly poorer than 70° and 100° samples

DISCUSSION

Evaluation of mustard packed in glass jars fitted with a new plastic lid was completed and was recommended for approval for use in the military level C (minimum protection) feeding system (see Appendix A). The idea of switching from a metal cap to a plastic cap was proposed by the Defense Personnel Support Center Value Engineering Change Proposal 49-83 (see Appendix B).

In order to evaluate the merits of this suggestion, the product was taken through a simulated life cycle approximating world-wide distribution systems. The product, packed in appropriate V3c RSC packaging described in PPP-G-460, was subjected to high-intensity vibration to determine if any loosening of the caps and leakage of the jars occurred. The plastic caps did not loosen or leak when subjected to this stress. Therefore, the next phase of the program was to test the quality of the product at designated intervals when stored under three temperature conditions for a year. Products were withdrawn, opened, and evaluated by a 30-member panel. Data (Table 1) indicate that mustard products were rated in the "(6) like slightly" to "(7) like moderately" categories, with no significant differences as to main treatment effect. At the six-month withdrawal period, the $100^{\circ}F$ mustard rated significantly lower than its $40^{\circ}F$ control and $70^{\circ}F$ counterparts. This effect was not seen again.

As the mustard at $100^{\circ}F$ aged, its color turned from a light yellowish-brown to a darker brown. This had little or no noticeable effect on acceptance. In addition, the product developed a slight surface skin at the top fill line near the cap, but the skin readily mixed in when stirred and was not discernible during use. Panel members did not always agree as to rating scores on mustard, since the standard deviation was greater than one, indicating moderate disagreement. This is not considered unusual, because the panel members are chosen at random and are from different age and ethnic groups, and many originate from different parts of the country.

The chemical parameters (figures 2 thru 8) were chosen from specification requirements for Mustard, Prepared, Federal Specification EE-M-821. As is shown, the values for pH (figure 2); acidity (figure 3); apparent viscosity (figure 4); percent solids (figure 5); percent crude fiber (figure 6); percent nitrogen (figure 7); and for volatile acidity (figure 8) were determined for samples stored at 40°F, 70°F and 100°F at five different withdrawal times.

Data in Figure 2 for pH indicated similar trends for each of the three temperatures, except for sample stored for 12 months at 100°F; its pH fell. All samples had a pH ranging from 3.32 to 3.47. This met the specification requirement for not less than 3 or more than 4.

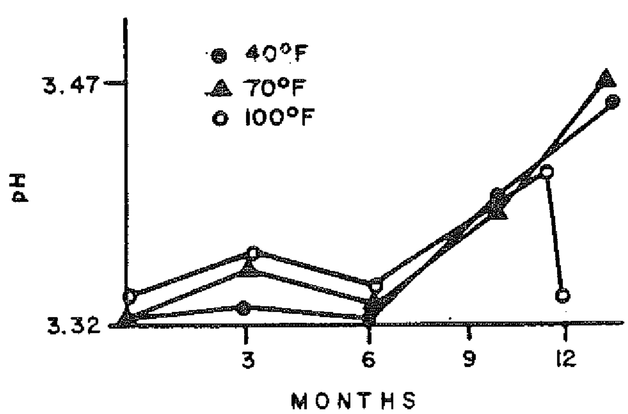

Figure 2. Effect of three storage temperatures upon pH.

Figure 3 shows the effect of storage and temperature on the titratable acidity of mustard expressed as percent acetic acid. The acid content of the product ranged from 3.02 to 3.41 percent. All product samples at designated withdrawal times and temperatures showed similar trends in titratable acidity rising slowly at first, and then rapidly, after 6 months. After 6 months, the product leveled off and the 40OF sample had a lower titratable acidity. The specification requirement for mustard of not less than 3 or more than 4 titratable acidity was continually conforming.

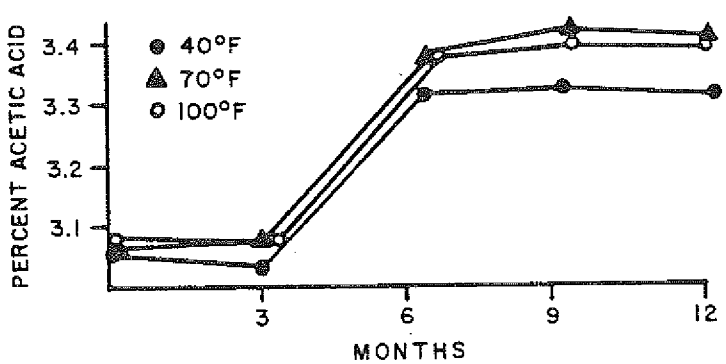

Figure 3. Effect of three storage temperatures upon titratable acidity.

Figure 4 shows apparent viscosity for mustard and was determined using a Brookfield viscosimeter, expressed in centipoises (cps). Viscosity ranged from 11,505 to 14,371 with the 40°F sample being more fluid than its 70° or 100°F sample counterparts. There are no present requirements in the mustard specification for apparent viscosity by chemical assay, except that we cite a major defect for "not smooth in consistency." Apparently, a new requirement should be added to protect the Government from getting a "watery-like" product.

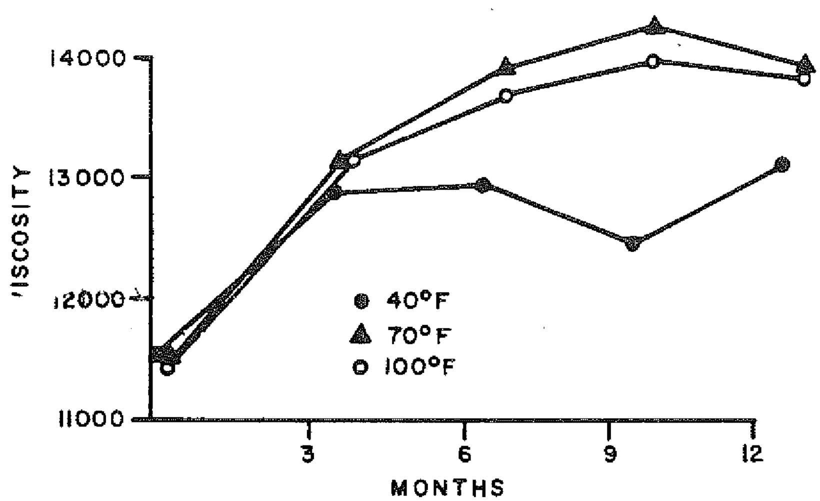

Figure 4. <u>Effect of three storage temperatures on apparent viscosity (cps).</u>

Figure 5 data indicate that the salad type mustard lost moisture after 12 months storage at 70°F and 100°F. Moisture was a low order loss, being only 2.2 percent gain in solids content. The sample at 40°F showed little or no change in solids. All samples of the product conformed to the specification requirement for total solids of "not less than 16.0 percent."

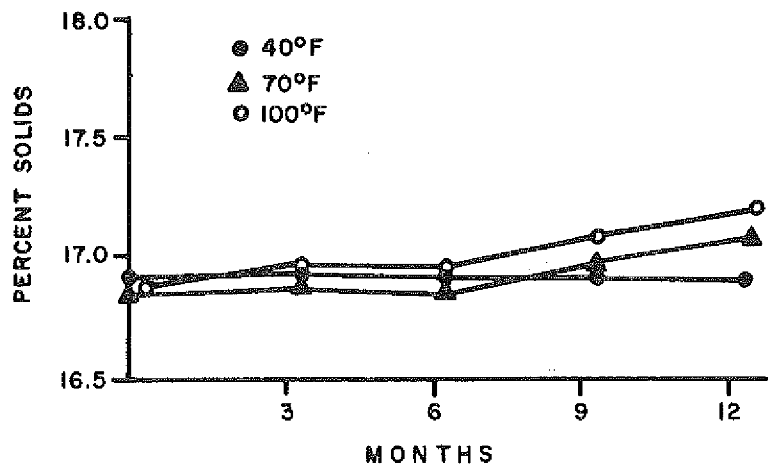

Figure 5. Effect of three storage temperatures on percent solids.

Figure 6 shows the percent crude fiber of mustard. Crude fiber contains about two-thirds of its insoluble content as cellulose with no soluble material remaining according to "Analytical Progress" in the Medallion Laboratories report of Feb. 1985, Vol. 2, No. 1, pp 1-6.[7] The samples varied in their crude fiber content with values ranging from a low of 2.01 to a high of 2.58. As the samples got older, the crude fiber dropped. This is not surprising, since no soluble material is measured in the crude fiber assay, and high temperature caused the crude fiber value to decrease, except for the 70°F sample at 3 months' storage time. The product conformed to the specification for crude fiber of "not more than 7 percent."

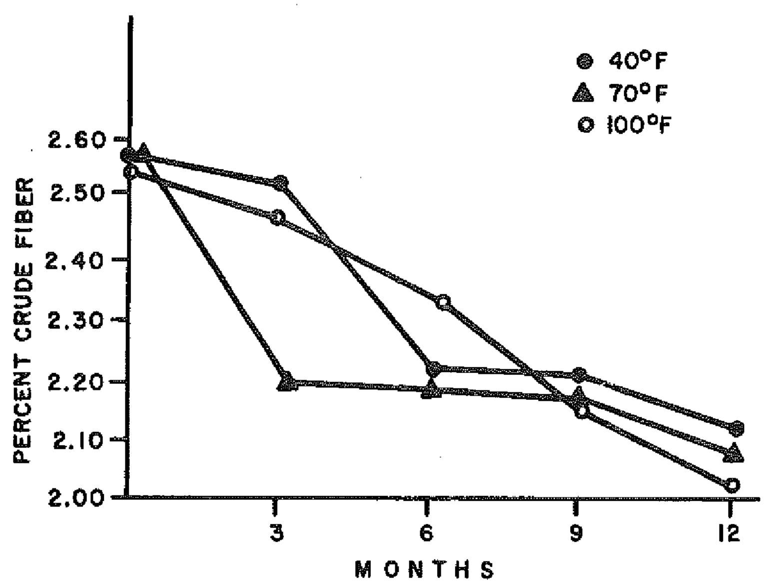

Figure 6. Effect of three storage temperatures on percent crude fiber.

Figure 7 shows percent nitrogen of mustard. The percent nitrogen value times 6.25 equals percent protein, or 4.5 percent, initially. This value conforms to the specification of not less than 3.8 percent. The protein value of the 100°F sample was more elevated at 3 months, but remained about equivalent to other samples throughout the 12 months' time period at the three storage temperatures.

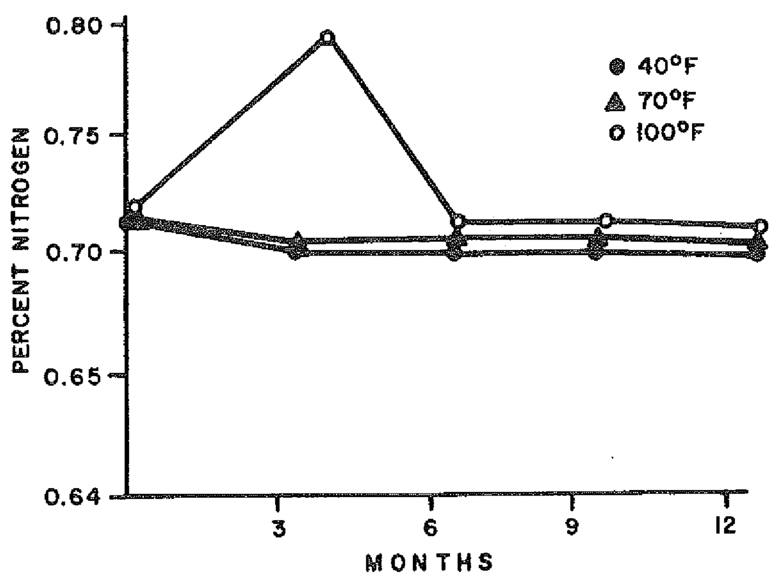

Figure 7. Nitrogen value of mustard.

Figure 8 shows volatile acidity of mustard expressed as percent acetic acid. We would expect the value to fall in a straight line as the samples got older or were stored at a higher temperature, but this phenomenon did not happen and cannot be explained. All samples showed a similar pattern, with the highest volatile acidity occurring at 6 months. The sample stored at 100°F had the highest volatile acidity. No specification requirement is cited for this parameter.

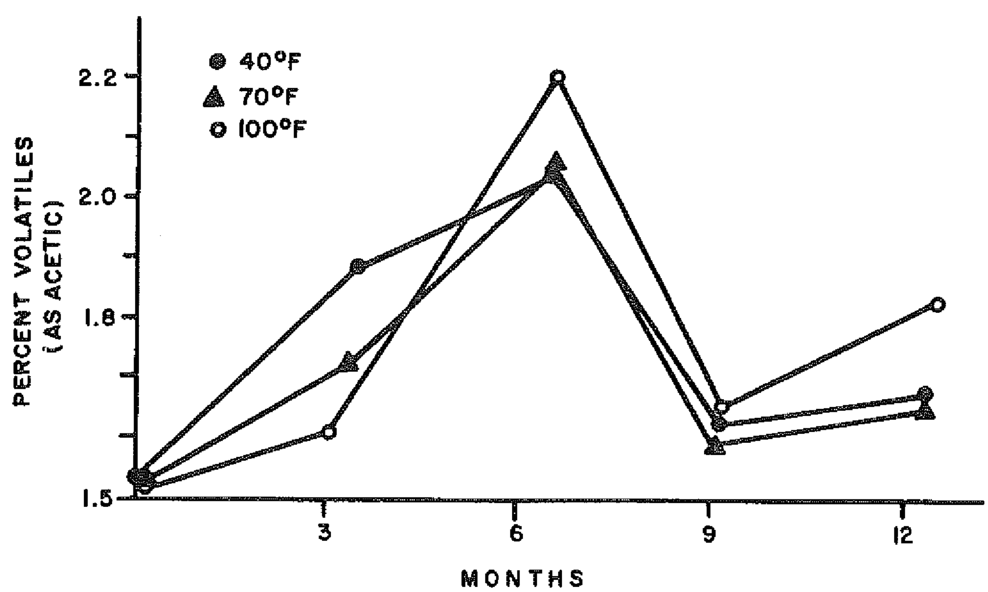

Figure 8. Volatile acidity of mustard (percent acetic acid).

Conclusions

Replacement of metal closures with Sun Coast plastic closures on jars of prepared mustard, as recommended by Robbins Sales, was successful.

Initially, prepared mustard conformed to all of the specification requirements of Federal Specification EE-M-821, type 1, and was found to be a very stable product on long-term storage (one year at 100oF), with little or no loss in acceptance. Chemical changes were monitored, as well as apparent viscosity.

Recommendations

Plastic lids are satisfactory replacements for the metal lids with pulp liners used as closures on jars of prepared mustard.

Level C packaging is recommended to provide minimum protection.

It is also recommended that the government standardize the materials and designs that will protect the mustard product as required. Inferior plastic caps that can loosen or leak are not suitable alternatives to metal caps with pulp liners.

Plastic caps with the good features stated above could be used on other food jars as the state of the art progresses.

In addition, a plastic shrink tape around the cap would stop the caps from loosening and reduce product tampering.

Literature Cited:

1. Amini, M.A. and D.R. Morrow 1980. Performance Evaluation of High Density Polyethylene Linerless Closures for Sun Coast Plastic Closures, Inc., Rutgers U. College of Engineering Report, Piscataway, New Jersey

2. Federal Specification EE-M-821H and Amendments 1975. Mustard, Prepared, U.S. Govt. Printing Office, Washington, D.C.

3. Federal Specification PPP-G-460C 1976, Glass Containers, Filled and Closed, Packaging and Packing of, U.S. Govt Printing Office, Washington, D.C.

4. ASTM Standard D999-75 1981. Standard Methods for Vibration Testing of Shipping Containers, American Society for Testing Materials, Philadelphia, PA

5. Peryam, D.R. and F.J. Pilgrim, Hedonic Scale Method of Measuring Food Preferences. FOOD TECHNOLOGY, Vol 11, No. 9, 1957, pp 9-14

6. AOAC 1984. "Official Methods of Analysis", 14th ed. Association of Official Analytical Chemists, Washington, D.C.

7. Medallion Laboratories Analytical Progress Total Dietary Fiber -- Another Look, 1984, Vol 2, No. 1, Minneapolis, MN

APPENDIXES

A: Levels of Packaging

B: Value Engineering Correspondence

APPENDIX A: Levels of Packaging

APPENDIX A: Levels of Packaging

Excerpt from:

AR 700-15/NAVSUPINST 4030.28B/AFR 71-6/MCO 4030.33B/DLAR 4145.7

"Governmental Maritime Consultative Organization (IMCO) for international vessel, International Air Transport Association (IATA) for international air. Tariff 6D for commercial domestic air shipments, AFR 71-4/TM 38-250/NAVSUPPUB 505/MCO P4030.19D/DLM 4145.3 for military air shipments. Transportation through the Defense Transportation System is covered in DOD 4500.32-R.

u. In selecting packaging in support of Security Assistance Programs, use the guidance from the directives that apply to these programs.

v. Automated systems for the selection of levels of protection will be reviewed at least annually for the adequacy of the decision logic.

w. DOD components will furnish design and function data on all specialized reusable containers in accordance with MIL-STD-1510. This information will be sent to the Container Design retrieval system (CDRS) Management Office (AD/YXC), Eglin Air Force Base, FL 32542. When it is determined that a specialized container design is required, the CDRS will be interrogated by the procedure in MIL-STD-1510.

2-2. Levels of protection
The following levels of protection apply equally to preservation and packing:

a. Level A. This packaging provides maximum protection. It is needed to protect materiel under the most severe worldwide shipment, handling, and storage conditions. Preservation and packing will be designed to protect materiel against direct exposure to extremes of climate, terrain, and operational and transportation environments, without protection other than that provided by the pack. The conditions to be considered include, but are not limited to -

(1) Multiple handling during transportation and intransit storage from point of origin to final user.

(2) Shock, vibration, and static loading during shipment.

(3) Loading on shipdeck, transfer at sea, helicopter delivery, and offshore or over-the-beach discharge, to final user.

(4) Environmental exposure during shipment or during intransit operations where port and warehouse facilities are limited or nonexistent.

(5) Outdoor storage in all climatic conditions for a minimum of 1 year.

(6) Static loads imposed by stacking.

b. Level B. This packaging provides intermediate protection. It is needed to protect materiel under anticipated favorable environmental conditions of worklwide shipment, handling, and storage. Preservation and packing will be designed to protect

materiel against physical damage and deterioration during favorable conditions of shipment, handling, and storage. The conditions to be considered include, but are not limited to --

(1) Multiple handling during transportation and intransit storage.

(2) Shock, vibration, and static loading of shipments worldwide by truck, rail, aircraft, or ocean transport.

(3) Favorable warehouse environment for a minimum of 18 months.

(4) Environmental exposure during shipment and intransit transfers, excluding deck loading and offshore cargo discharge.

(5) Stacking and supporting superimposed loads during shipment and extended storage.

c. Level C. This packaging provides minimum protection. It is needed to protect materiel under known favorable conditions. The following criteria determine the requirements for this degree of protection:

(1) Use or consumption of the item at the first destination.

(2) Shock, vibration, and static loading during the limited transportation cycle.

(3) Favorable warehouse environment for a maximum of 18 months.

(4) Effects of environmental exposure during shipment and intransit delays.

(5) Stacking and supporting superimposed loads during shipment and temporary storage."

APPENDIX B: Value Engineering Correspondence

DISPOSITION FORM

For use of this form, see AR 340-15; the proponent agency is TAGO.

REFERENCE OR OFFICE SYMBOL	SUBJECT
DRDNA-EPT	VECP Robbins Sales Co. Inc., Contract DLA13H-83-C-7895, Allow Plastic ILO Metal Lid. Prepared Mustard Jar, DPSC-S-VECP-49-83

TO Dir, FEL
ATTN: LTC Scharding

FROM VEPM, EPMC

DATE 17 August 1983
E.F.Sylvia/tcc/4353

CMT 1

1. Reference DRDNA-WP Comment 2 dated 22 July 1983, subject as above.

2. Enclosed for your information and retention is copy of Rutgers University Report on Polyethylene Linerless Closures.

1 Encl
as

DANIEL F. SHIMKUS
Value Engineering Program Manager

CF:
C, DFD, EPMC
C, SM Br, EPMC

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AUG 8 - 1983

IN REPLY REFER TO DPSC-STS (Knesbach/X2979/jms)

SUBJECT: VECP, Robbins Sales Co, Inc, Contract DLA13H-83-C-0895, Allow Plastic ILO Metal Lid - Prepared Mustard Jar, DPSC-S-VECP-49-83

TO: Commander
U.S. Army Natick Research and Development Laboratories
ATTN: DRDNA-EPT

1. References:

a. Letter, DRDNA-EPT, 1 Aug 83, subject as above.

b. Letter, Robbins Sales Co., Inc., 3 Jun 83, subject as above.

2. Additional information provided by the contractor is forwarded for your information.

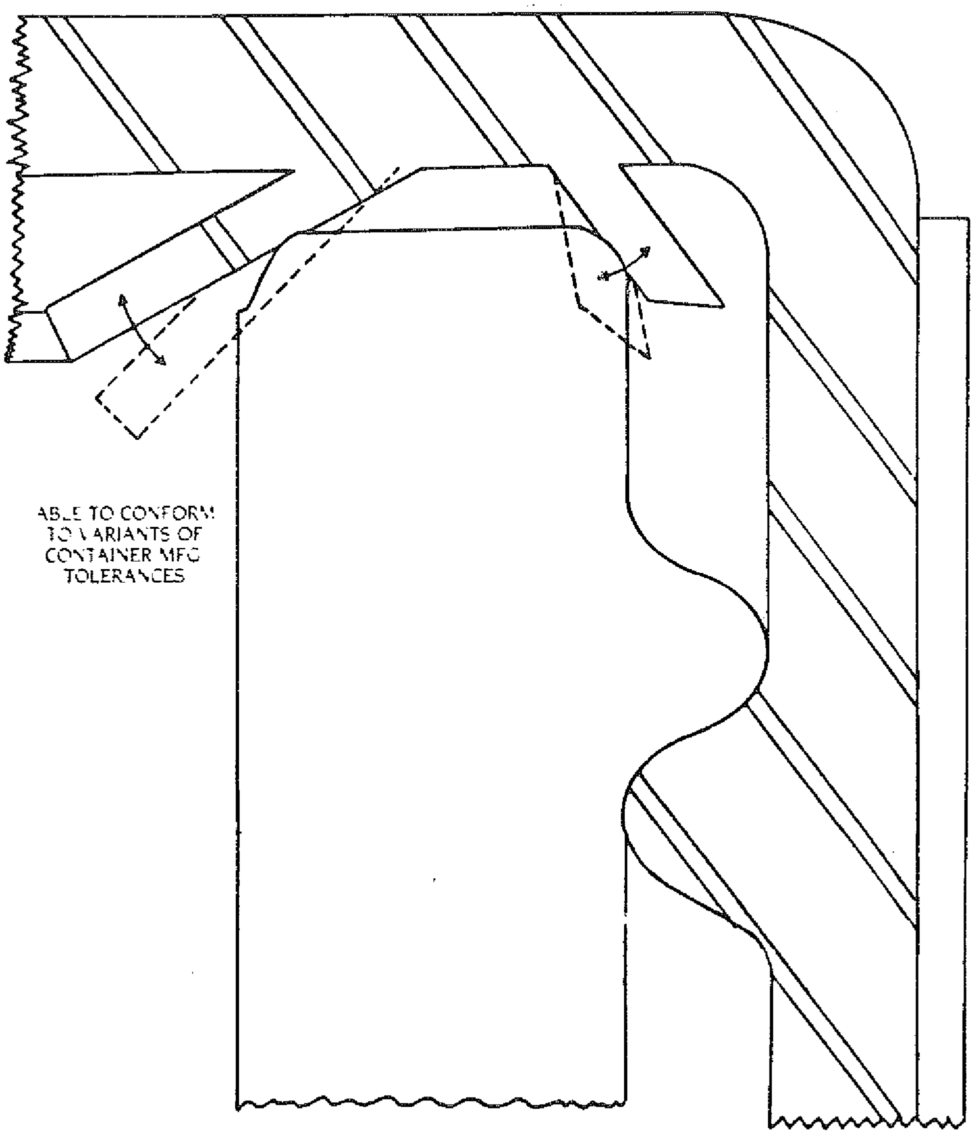
3. The Rutgers University report as requested in reference 1.a. is also enclosed. We will send you a copy of the manufacturer's technical specification for plastic lids, provided the contractor can obtain one.

FOR THE COMMANDER:

Encl 2

ALFRED L. SAVICH
Chief, Tech Services Branch
Tech & Qual Assur Division
Directorate of Subsistence

CLOSE-UP OF EDGE SEAL™



Sun Coast Plastics, Inc